

HITCHHIKER MISSION OPERATIONS

Past, Present and Future

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ABSTRACT:

What is mission operations? Mission operations is an iterative process aimed at achieving the greatest possible mission success with the resources available. The process involves understanding of the science objectives, investigation of which system capabilities can best meet these objectives, integration of the objectives and resources into a cohesive mission operations plan, evaluation of the plan through simulations, and implementation of the plan in real-time.

In this paper, the authors present a comprehensive description of what the Hitchhiker mission operations approach is and why it is crucial to mission success. The authors describe the significance of operational considerations from the beginning and throughout the experiment ground and flight systems development. The authors also address the necessity of training and simulations. Finally, the authors cite several examples illustrating the benefits of understanding and utilizing the mission operations process.

INTRODUCTION

The mission operations process starts at the earliest stages of Hitchhiker Project and customer interaction and culminates in on-orbit operations. Experience has proven that an attention to operations is integral to the development and ultimate success of a Hitchhiker Payload.

Ideally, payload operations activity begins even before an experiment is manifested as a shuttle payload. At this stage, when experiments are still being conceptualized, mission operations plays a crucial role. A customer can design an experiment to maximize the possibility of mission success by understanding the capabilities and limitations of the Hitchhiker and Orbiter systems up front.

The Hitchhiker operations group aims to capitalize on the wide range of services and capabilities available to Hitchhiker customers. As the team investigates which capabilities can best meet science objectives, compatibility between payload requirements and Space Shuttle Program (SSP) resources is determined. Mission Operations is a driving factor in the definition of the Space Shuttle Manifest.

Once a payload is manifested on a compatible flight, requirements and resources are integrated into a cohesive

mission operations plan through an interactive dialogue between Hitchhiker, Orbiter, and experiment personnel. The resulting operations plan prepares and guides the Hitchhiker Flight Operations Team (FOT), consisting of both operations personnel and experiment teams, through both nominal and contingency flight situations.

MISSION OPERATIONS PLANNING

Mission planning is a multi-faceted and interactive process, as illustrated in Figure 1. Early reviews are essential in the planning of flight timelines and procedures. Operations training, provided through all stages of payload development, plays a fundamental role by introducing the capabilities and constraints of the Hitchhiker and Orbiter systems. Knowledge of these constraints aids in the development of hardware, software, and mission operations documentation and plans. Once the flight activities and requirements have been documented and the Hitchhiker ground system has been verified, the Hitchhiker operations group prepares experimenters for real-time operations through further classroom training and interactive simulations.

The mission planning process involves years of preparation which culminate in a relatively brief period of flight. As the mission success of the payloads, not to mention the safety of the Orbiter and crew, are dependent upon the thorough

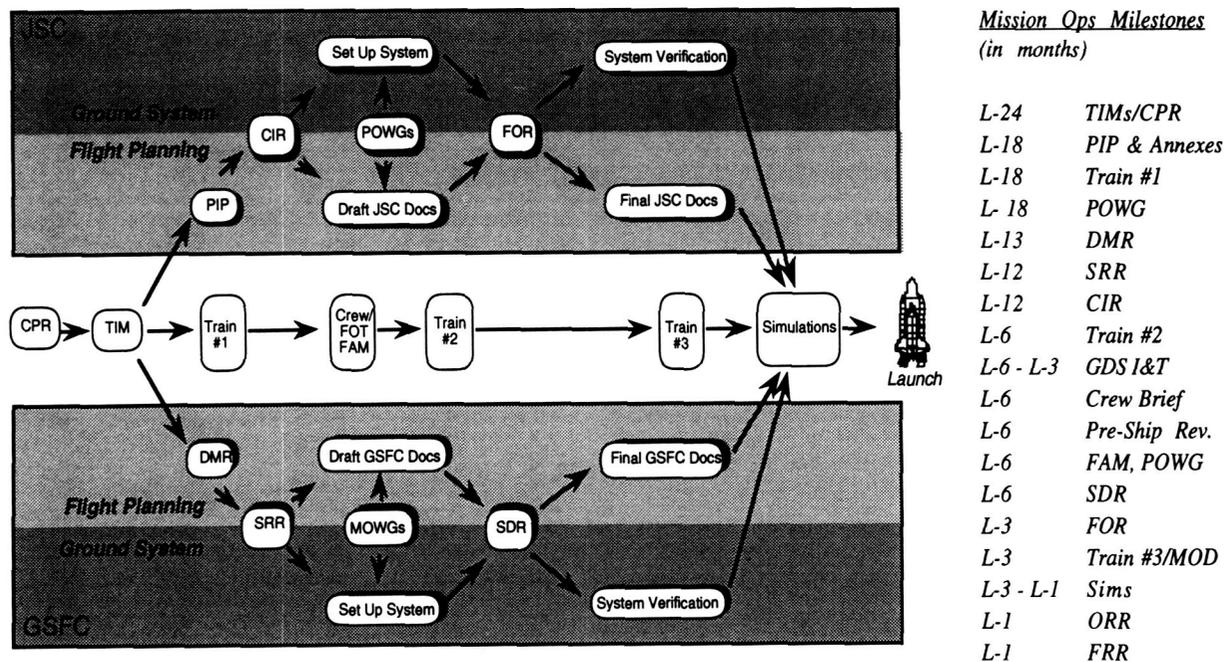


Figure 1: Mission Planning Process

<i>Documentation/Event</i>	<i>Corresponding Review</i>
• Customer Payload Requirements (CPR)	• Technical Interchange Meeting (TIM)
• Training #1/ Payload Integration Plan (PIP)	• Payload Operations Working Group (POWG) • Cargo Integration Review (CIR)
• Detailed Mission Requirements (DMR)	• System Requirements Review (SRR) • System Design Review (SDR) • Ground Data System I&T (GDS I&T)
• Ship to KSC	• Pre-Ship Review
• Document Publication/Training #2 • Crew Brief/Familiarization Brief (FAM)	• Payload Operations Working Group (POWG) • Flight Operations Review (FOR)
• Simulations/Training #3 • Mission Operations Document (MOD)	• Sim Debrief
• "GO" for Launch	• Operational Readiness Review (ORR) • Flight Readiness Review (FRR)

planning and preparation of the entire flight team, final simulations and reviews are held to verify the flight readiness status of all supporting elements, both human and mechanical.

Flight Operations Documentation/Meetings

Payload Requirement Definition

The earliest stage of the mission operations planning process is concentrated about the generation of documentation within the customer's facilities and at the Goddard Space Flight Center (GSFC). Early technical interchange between the Hitchhiker team and the customer is crucial in the definition of payload requirements and the development of the

experiment flight and ground systems. These preliminary meetings, designated Technical Interchange Meetings (TIMs), are ideally scheduled approximately two years prior to flight. TIMs provide a forum for the discussion of payload requirements and goals as defined in the agreement between the Hitchhiker Project and the customer, the Customer Payload Requirements (CPR) Document. The CPR contains a myriad of detailed experiment information: operation cycles, crew involvement, command/telemetry requirements, power requirements, ground system requirements, Orbiter pointing restrictions, instrument field of view, descriptive material and mission objectives. The Mission Manager (MM) utilizes the CPR and information gathered at TIMs to oversee the integration of the customer's experiment with the Hitchhiker and Orbiter communities.

In preparation for the TIMs, the MM gathers lead personnel from various disciplines supporting Hitchhiker missions to discuss payload integration issues and payload operational requirements and constraints. The team leads are then responsible for generating and maintaining documentation of payload requirements and specifications for submittal to the Johnson Space Center (JSC). The Operations lead, designated the Operations Director (OD), maintains an ongoing dialogue with the customer point of contact throughout the mission operations planning process and verifies his/her work through customer feedback. The OD also supports payload status meetings to determine if payload development and integration issues could impact mission operations.

The OD supplements the TIMs with preliminary mission operations training sessions, providing the customer with an early awareness of the operational capabilities and constraints of the Orbiter and Hitchhiker systems. From these sessions, an expanded definition of payload requirements materializes and the OD begins to analyze customer requirements versus the wide range of services and capabilities available.

As payload development progresses, the OD integrates payload requirements into both joint (between the JSC and all payloads) and Hitchhiker specific documentation and support JSC in the final preparation of these documents. Hitchhiker specific documents are developed defining internal operations to be followed by the Hitchhiker FOT. The operations training provided throughout development aids in the definition and refinement of these requirements. Engineering and operations reviews are held throughout the mission planning process to analyze the compatibilities/conflicts between various payloads.

Joint Mission Documentation and Related Reviews

Utilizing the information in the CPR, the Hitchhiker team leads prepare the Payload Integration Plan (PIP) and its annexes. The PIP is the contract between the Hitchhiker Project, on behalf of the customer, and the SSP. General mission operations information relating to those requirements that affect the manifesting of the Hitchhiker payload with other payloads is contained within the PIP. Specific mission operations requirements and specifications between the Hitchhiker program and the JSC SSP are defined in the PIP annexes. The OD prepares annexes covering electrical and power requirements, flight activity planning, flight operations support, crew training, and Payload Operations Control Center (POCC) interfaces and aids the MM in the development of the PIP. These documents form the basis for detailed operations documentation by outlining specific Hitchhiker customer requirements and mission objectives. Payload Operations Working Group (POWG) meetings may be called to support the definition of payload

requirements and to resolve any issues during the development process.

After submittal of the PIP and Annexes to the JSC, payload representatives attend a Cargo Integration Review (CIR) at which the SSP assesses the compatibilities between the manifested payloads as well as the capabilities of the SSP to meet payload requirements. As stated earlier, mission operations requirements are a driving factor in the consideration of payload compatibility. Once the SSP feels confident that all mission requirements can be met, the shuttle manifest is formally solidified and the PIP and Annexes are baselined.

A basic version of all flight documentation products, including the Flight Data File (FDF), is then developed from the requirements in the baselined PIP and Annexes. The FDF is the total on-board complement of documentation and related aids available to the crew for execution of the flight, including operations plans, crew checklists, and reference data. The Flight Plan is the most significant component of the FDF as it is the control document for on-orbit operations, tying mission operations together by timelining the crew, Orbiter and payload activities. The Flight Plan is developed pre-mission and is updated daily during the flight. Various other documentation is developed to coordinate ground operations. These documents govern nominal procedures and define payload priorities and constraints for consideration in contingency scenarios.

All flight operations documentation is published in basic form approximately 6 months prior to launch. At this time the documents undergo extensive review by mission personnel. The OD involves the customer in this review after providing training on how to read and interpret flight documentation. The OD then submits any discrepancies to the published documentation to the SSP at the Flight Operations Review (FOR). The OD represents the customer at the FOR to ensure that all payload requirements are properly reflected in the final set of flight documentation products, which are used for both simulations and on-orbit operations.

The documentation process is fundamental to flight preparation and mission planning. The OD and the MM use the flight documentation to ensure that payload operational requirements and constraints are not intentionally violated during the flight. These documents facilitate mission operations by prioritizing and organizing on-orbit activities while also providing an assurance that all feasible efforts will be made to preserve and achieve payload goals.

GSEC Specific Documentation and Related Reviews

The overall objective of the Hitchhiker Project is to provide service to a variety of customers via standard interfaces as

defined in the Customer Accommodations and Requirements Specifications (CARS) document that can be used for experiment design and development, as well as mission operations. To this end, the Hitchhiker Ground Data System (GDS) utilizes standardized capabilities available at the GSFC. The OD provides training on these capabilities and works with the customer to define which services will best meet their needs.

Utilizing this information, the OD, in consultation with the Mission Support Manager (MSM), determines which GSFC elements are required to support the mission and outlines these requirements in the Detailed Mission Requirements (DMR) document. The MSM, who is responsible for the configuration of the GDS, then monitors the design and implementation of the requirements through a detailed review process.

As the DMR outlines the requirements of the Hitchhiker GDS, the Mission Operations Document (MOD) generated by the OD outlines the operational procedures to be utilized within the POCC. The MOD provides Hitchhiker operations personnel with guidelines to ensure an orderly and efficient operations center, as well as pre-planned decisions to minimize the response time to anomalous events.

The customer is responsible for developing detailed experiment operational documentation governing experiment flight procedures, such as console procedures, command plans, and contingency recovery plans. These procedures guide real-time experiment operations within the Hitchhiker POCC during simulations and flight. Many customers use the Hitchhiker Timeline System (HTS) product as a guideline in the preparation of operational plans and procedures. The HTS, developed exclusively for the Hitchhiker Project, provides operations personnel with communication availability predictions, Orbiter pointing predictions and payload activity timelines. The HTS product is based on the Flight Plan and supporting JSC documents. However, unlike the Flight Plan it is updated at the POCC in real-time. This proves a valuable tool through training, pre-mission planning, and flight by providing the POCC with a locally controlled operations timeline as well as with planning information not readily available from the JSC during a Shuttle flight.

Regardless of the time spent preparing nominal plans, actual on-orbit operations often bring rise to contingency situations in which nominal operational scenarios become unsuitable. Thus it is important that customers take into account all possible operating scenarios, regardless of improbability, in preparation for a mission. Unlike a world of free-flyers, where scientists have days, if not months, in which to troubleshoot a problem, shuttle flights offer a relatively short period for implementation of the experiment timeline.

Pre-mission contingency planning is critical for a successful flight. The OD aids the customer in the development of off-nominal scenarios pre-flight and facilitates the on-orbit execution of contingency resolution in a timely and efficient manner.

All internal GSFC documents and reviews are geared towards the creation of a functional and operational ground system. As the DMR outlines the resource and service requirements of the payload, the MOD guides the daily activities and duties of the operations personnel, and the experiment procedures govern the real-time operations of the payload. The procedures and protocols in the MOD foster an atmosphere geared to the success of real-time operations.

Mission Training

In the early years of the Hitchhiker program, mission operations training was provided informally throughout payload development and presented in a formal session relatively close to flight. Although some experiments manifest as a Hitchhiker payload after system design is complete, some experiments manifest early enough in the development process for training to influence experiment design. Several customers have responded that an earlier insight into the resources of the Hitchhiker system would have helped them to design their experiments better by using more of the services available to them. Thus a new training approach has been adopted, one which offers formal training at at least three points through payload development and mission planning. This training is offered early and is repeated often throughout the development process.

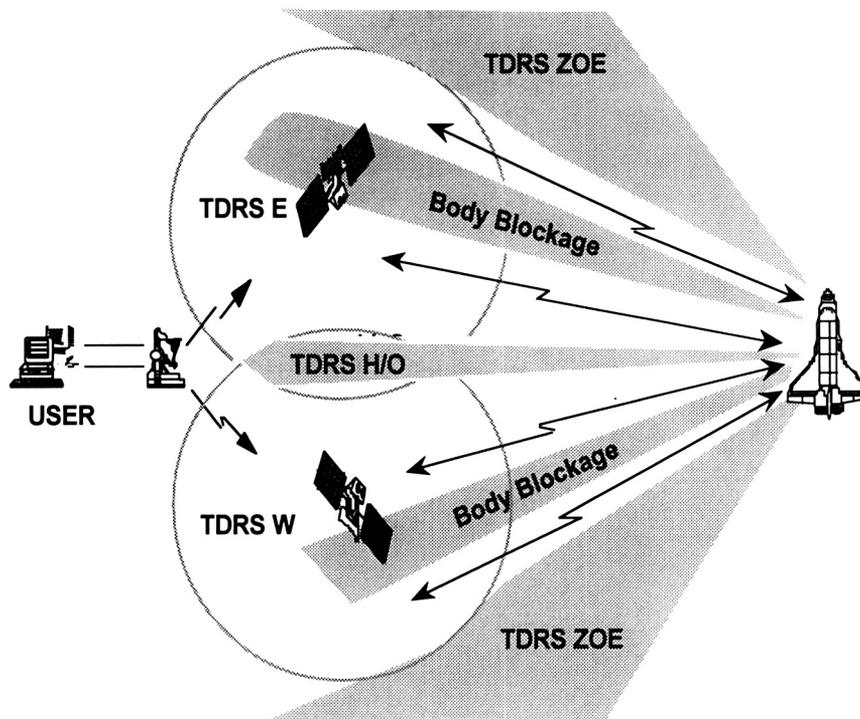
Mission Operations Training

Payload Mission operations are driven by the capabilities and limitations of the resources at hand. Understanding the nature of Orbiter to ground communications, standard operational contamination factors, and GDS capabilities is imperative for maximizing science return during a mission. To provide this essential Hitchhiker education, a series of classroom training sessions is held to familiarize customers with Hitchhiker and Orbiter services, data systems configurations, and all aspects of mission operations as shown in Figure 1.

The first training session introduces the capabilities of the Orbiter telecommunications systems, addresses the concept and function of the Hitchhiker ground system, and summarizes contamination factors that may impact payload operations. This session plays an important role in payload development as experimenters can channel the design of their hardware and software both on-orbit and on-ground to the capabilities and constraints of the operational systems. For

This diagram illustrates only a small portion of the operational systems and or factors which often enhance, and sometimes degrade, yet always dictate, Hitchhiker mission operations.

Hitchhiker experiments produce low rate (LR) and medium rate (MR) data which is transferred to the ground through the Orbiter S-Band and Ku-Band systems via the Tracking Data and Relay Satellite (TDRS) System (TDRSS). The Orbiter records LR data during Loss of Signal (LOS); MR data is not recorded. Communications via the TDRSS can be constrained by many factors, such as loss of sight to a TDRS due to the TDRS Zone of Exclusion (ZOE) or structural blockage, handovers of communications from one TDRS to the other, corrupted or weak communication signals due to interference, or conflicting Orbiter or payload requirements for dedicated satellite communications.



Shaded areas indicate a loss of communications between the Orbiter and the TDRSS.

Figure 2: TDRSS Communication Constraints

example, experiments relying heavily on medium rate data may be influenced to add a recording device onto their payload to ensure that communication outages, some of which are illustrated in Figure 2, will have a minimum impact on their operations planning. Other experimenters may opt to design their command interface to allow serial commands in lieu of basic bi-level operations.

This initial training also plays an important role in the definition and requirement of system constraints. A flight constraint may sometimes be no stricter than a requirement that the Hitchhiker POCC be notified prior to a deviation from the planned contamination event or timeline. The reasons for this are two-fold: to safe instruments that may be wary of contamination yet who do not require an inhibit, or to enhance the science opportunities for payloads wishing to observe contamination events.

The most important function of this preliminary training session is to raise experimenter awareness of all of the factors that will dictate mission operations. The training provides the information necessary for the customer to levy informed requirements and constraints on the SSP through the operations documentation outlined before.

The second operations training session describes flight and ground documentation used during on-orbit operations. These documents form the basis for all payload operations and coordination. It is vital that experimenters can interpret and understand the flight documents which outline all mission operations. The OD instructs the customer on how to read the Flight Plan, Operations Timelines, Attitude Timelines and the HTS, with emphasis on all details which will prove critical in timelining experiment operations. The customer learns how to use the HTS as a mission planning tool, above and beyond those provided by JSC. The OD presents this training as soon as the basic version of flight documents are published, facilitating customer participation in the FOR process.

The final mission training session is held immediately prior to the first simulation. This training focuses on real-time operations within the control center. The OD introduces many JSC-generated products which will be utilized in real-time during the mission and simulations, such as the Execute Package (Flight Plan). Additional Hitchhiker-specific products such as the HTS, contamination schedules, and status reports will also be distributed regularly to all users in the POCC during missions and simulations. The OD presents the MOD which outlines the important procedures that govern day-to-day operations within the POCC, such as shift handover guidelines, shift reports, and

voice protocol, and covers the distribution of products outlined above. The classroom session is supplemented with hands-on familiarization with POCC equipment.

The expansion of the training process through all stages of payload development offers more flexibility in customer support and involvement. Training sessions are often performed multiple times to train additional personnel or simply to reacquaint those previously trained with highlights from earlier sessions.

Crew/JSC Flight Operations Team Training

Approximately six months prior to launch, the MM, the OD, and the customer hold a Familiarization Briefing at the JSC to train the JSC FOT on the Hitchhiker payload. Around the same time, the crew visits the GSFC for the Crew Briefing at which the crew is briefed on the Hitchhiker payload goals and operations and views the payload hardware. Although crew involvement in the majority of Hitchhiker payloads operations has been generally limited to activation and deactivation of the payload and the possible establishment of observation attitudes, some payloads place significant responsibilities upon the crew. Thorough training provided by the JSC Training Team under the direction of the OD is essential in the success of crew-intensive payload operations.

Ground Data System Development and Test

The Hitchhiker Mission Readiness Manager (MRM) is responsible to the MSM for providing and verifying the Hitchhiker GDS ground system based on the DMR requirements. The Hitchhiker MRM verifies the functionality of the GDS with the payload and the JSC MCC through a series of tests beginning in conjunction with the payload integration activities and continuing until launch.

Customer experiments are delivered to the GSFC where they are electrically and mechanically integrated to the Hitchhiker carrier. After all experiments have been fully integrated, the MRM conducts a POCC Test to verify the end-to-end capability of the Customer Ground Support Equipment (CGSE), located at the Hitchhiker POCC, to communicate with the payload via the GDS. During these tests, telemetry from the payload is recorded for use in future interface tests and simulations in lieu of a real-time payload telemetry stream. The OD and the Sim Sup may script an operational scenario to run through during this test as a script allows for operational sequence evaluation and provides greater dynamics to data played back during the simulations. Following these activities, the payload is shipped to the Kennedy Space Center (KSC) where it is unpacked and readied for installation and flight.

Further tests using taped data are performed to verify all

interfaces and support elements that will comprise the operational GSFC GDS. Finally, the MRM schedules additional tests prior to each Joint Integrated Simulation (JIS) and launch to verify the command and LR telemetry interfaces between the JSC MCC and the GSFC.

Simulations

Once the Hitchhiker GDS has been verified and both joint and internal mission documents have been developed, operational simulations are conducted to verify operational procedures and exercise the communication between all operators. These simulations do not test how well experimenters know their systems; they evaluate whether the plans and procedures for real-time operations are satisfactory.

Simulations are supported by the entire Hitchhiker FOT, composed of all operators required for real-time support during the mission, including the Mission Manager, the experimenters, the Operations Directors and all supporting personnel within the POCC. Simulations allow the experimenters to apply the knowledge gained in the training sessions in a realistic environment. They provide familiarity with the control center environment, POCC operations and procedures, and both inter and intra-center coordination. Simulations also result in a diverse forum of FOT personnel who can benefit each other through the sharing of operational experience and lessons learned. 'Novice' Hitchhiker customers can learn from the experiences of flight 'veterans'; while experimenters with previous Hitchhiker experience can learn once again how to function within a diverse and intense team environment. The Hitchhiker operations group attempts to cultivate this team environment throughout the simulations with the aim of a cohesive and integrated FOT.

The Hitchhiker Program supports two kinds of simulations: Goddard Internal Simulations (GISs) and JISs. GISs exercise operational procedures and train personnel in POCC procedures. During GISs, the Hitchhiker ground system is configured using only GSFC facilities. Some supporting elements simulate the JSC by receiving commands from the POCC and playing back recorded payload telemetry to the experiments. These simulations test GSFC internal data, management, and operations interfaces and emphasize Hitchhiker POCC procedures.

JISs establish operability of the overall ground system including the links to the JSC Mission Control Center (MCC). During the JISs, the ground system is configured as for mission operations. The JSC MCC receives Hitchhiker commands and forwards a composite telemetry stream back to the GSFC except for the Hitchhiker data which is simulated via playback of Hitchhiker payload telemetry recorded during the POCC Command Test.

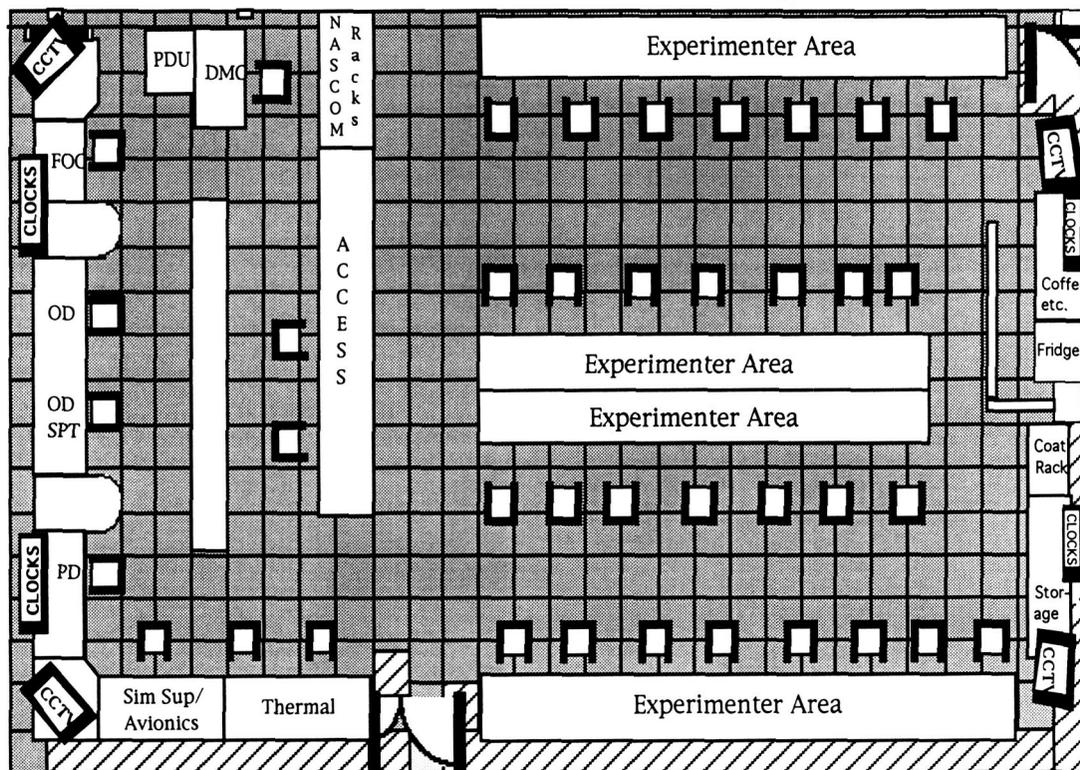


Figure 3: Hitchhiker POCC Layout

JISs are treated as an actual flight for the crew and all flight controllers and involve all facilities participating in the mission including the GSFC, the JSC and other remote POCCs. The crew participates from the Shuttle Mission Simulator (SMS) at the JSC which provides realistic shuttle subsystem data for the simulation. Coordination between the JSC MCC, the Hitchhiker POCC, and other payloads is emphasized during these exercises. System malfunctions are introduced which impact the mission community as a whole and require extensive inter-center coordination and replanning operations. These situations often require analysis of Orbiter resources and payload priorities and test the operational decisions outlined in the flight documentation.

Simulations provide a medium to evaluate the effectiveness of the operations plan and to develop both situational awareness and contingency resolution skills in an environment representative of the actual mission, thus providing the best available hands-on experience for experimenters about to launch into real-time operations.

REAL-TIME MISSION OPERATIONS

The mission operations process culminates in the real-time implementation of the comprehensively developed, thoroughly evaluated operations plan. The ultimate

responsibility of the OD is to guide and represent the customer, champion their interests, and coordinate real-time changes to the plan from launch through landing.

Hitchhiker operations are conducted in real-time based on overall plans prepared pre-mission. The Hitchhiker payload is assigned operating periods scheduled according to the requirements of all manifested payloads. Some payloads require dedicated Orbiter support such as attitude control or crew interaction. The assignment of dedicated periods to all payloads is made based on their priority and large resource requirements including crew-time and power. The Hitchhiker FOT often must strive to take advantage of all events in the flight plan and all available resources to accommodate Hitchhiker science objectives.

While higher priority payloads are being supported, the Hitchhiker may only be allowed sufficient power for maintenance of payload electronics and thermal conditioning. Low rate data and commanding may only be provided for periodic evaluation of payload health and safety. However, there may be opportunities for the Hitchhiker payload to operate in parallel with (piggyback) other payload operations. Piggyback operations are background operations, which take advantage of available Orbiter resources and gain science data on a non-interference basis with primary payload activity. Contingency operations are supported from the Hitchhiker ground system using available real-time command capability.

Payload Operations Control Center

The focal point for Hitchhiker payload operations and management is the Hitchhiker POCC located at the GSFC in the Attached Shuttle Payload Center (ASPC). As a center part of the Hitchhiker GDS, the POCC provides efficient service to a variety of customers through simulations and real-time operations. It is designed for functionality with an attention to personnel comfort and can support several payloads and/or flights simultaneously.

The POCC is composed of a Mission Operations Area, an Experimenter Area and a Common Area, as illustrated in Figure 3, and accommodates all mission operations personnel and equipment. It also houses the Advanced Carrier Customer Equipment Support System (ACCESS): a PC-based, distributed network that provides the central interface between the CGSE and the outside world.

The POCC interfaces with the GSFC support facilities to provide telemetry and command for the Hitchhiker payloads. Additional GSFC supporting elements provide simulation support and attitude, orbit and data display generation. The POCC is equipped with a number of display devices, all with color capability, including large screen color monitors.

Real-time mission operations is the culmination of months, perhaps years, of careful preparation. An organized and efficient control center offering a complete set of tools for replanning and real-time operations is essential to mission success.

HITCHHIKER IN ACTION

In the years since its inception, the Hitchhiker program has sponsored many payloads, of which the following examples are but a small sampling. Although all missions have seen their share of obstacles, the majority of Hitchhiker payloads have been a resounding success. Both the obstacles and victories alike have brought forth valuable insight that contribute to the success of following flights. The Hitchhiker operations group learns from all successes and failures and is thus able to continuously broaden and improve its scope of service.

Superfluid Helium On-Orbit Transfer

The Superfluid Helium On-Orbit Transfer (SHOOT) payload which flew on STS-57 consisted of two vacuum insulated dewars (tanks) containing liquid helium connected by a transfer line, various instrument electronics, and control systems mounted on a Hitchhiker cross bay carrier. The objective of the SHOOT mission was to perform experiments demonstrating the technology and operations required to service payloads in space with liquid helium and to verify several cryogenic devices and procedures in the zero-g environment.

The majority of the operations involved the transfer of helium from one dewar to the other. Operations consisted of both ground-controlled and crew-controlled transfer of liquid helium. The crew used an Aft Flight Deck (AFD) computer for command and verification. These operations required real-time crew interaction and/or expert system software for diagnostic and control operations.

During payload development, the SHOOT customer was developing a high fidelity simulator to aid the crew in training with the AFD software. After discussions between the SHOOT customer, the MM, and the OD, the anticipated role of the simulator was expanded to include training of the entire FOT and use during all GISs and JISs. This resulted in very dynamic simulations that extensively exercised the coordination between the ground operators and the crew in a realistic environment. By providing realistic telemetry for both the ground and the crew, the simulator allowed the operations personnel to rigorously test both nominal and contingency SHOOT procedures. This SHOOT simulator provided an additional benefit: a critical failure in flight was simulated during one JIS, thus preparing the FOT for contingency resolution of the problem in real-time.

Despite some serious hardware problems on Flight Day 1, the SHOOT experimenters were able to accomplish all mission goals and milestones. They attributed this success to the great efforts of and coordination between the Goddard POCC, the MCC and the crew. They also attested to the value of the JISs in preparing the FOT to tackle real-time contingency resolution.

Robot Operated Materials Processing System

Mission operations often entails striving for science under less than ideal conditions. Yet experience has shown that the means for accomplishment are available, often just waiting to be recognized and channeled in the right direction. During the STS-64 mission, the Robot Operated Materials Processing System (ROMPS) payload required low-g environments through several crew sleep periods for critical sample processing. In order to accomplish the task, a wide attitude deadband was programmed into the Digital Auto Pilot (DAP) settings of the Orbiter. However, despite the wide deadbands, predictions showed that the Orbiter would still often reach the deadband limits too fast for a sample to finish processing.

The OD prepared for this situation pre-flight by coordinating closely with the Guidance Navigation and Control (GNC) Officer at JSC to be cognizant of the signatures of the respective Orbiter Control System burns. Thorough procedures were developed and put to the test during the simulations. Several modifications were made, allowing direct contact between GNC and the OD, bypassing the normal flight protocol through the Houston Payloads Officer. During the flight, the GNC and the OD worked closely together to trend the timing between firings and give

ROMPS an emphatic "go" when sample processing times were assured. Several times the samples finished baking with only seconds to spare. This close coordination between the JSC and Hitchhiker FOTs helped achieve full mission success while operating under what could otherwise be seen as difficult circumstances.

Shuttle Glow Experiment

The Shuttle Glow Experiment (GLO) has to date flown two times as a Hitchhiker payload, although several additional flights are currently manifested. The GLO payload consists of imagers and spectrograph assemblies and supporting electronics. The primary objective of the experiment is to observe and qualify both Orbiter and atmospheric glow in the 115 to 1150 nanometer spectral range. The GLO-I experiment aboard STS-53 experienced a combination of hardware problems and unlucky orbital conditions resulting from Orbiter and primary payload operations. As a result of primary payload requirements, the orbit trajectory was one in which the Orbiter did not have a night pass until the last day of the mission. Additionally, primary payload operations early in the flight led to propellant constraints, thus further limiting GLO observations. Due to these constraints the FOT had to restructure night observations originally scheduled throughout the flight to the last few orbits of the mission. This involved extensive prioritization, coordination, and replanning for both a nominal end to the mission and a sought for, yet ultimately denied, extension day.

The GLO-II instrument flew on STS-63, with upgraded hardware and a heightened insight into Orbiter operations that only a tough mission can bring. The GLO-II instrument experienced some hardware malfunctions which required much of the flight to troubleshoot. However, the FOT replanned GLO science operations and had an extremely successful flight, regardless of the difficulties encountered. STS-63 was a great learning experience for the entire FOT; several operational issues which arose during the flight and were resolved in real-time prepared operators for future flights of the GLO instrument.

The GLO-III experimenters have upgraded their instruments to add even more to their data ingestion capability; they have included an optical disk tape recorder which offers a great deal of data storage space. GLO recognizes the importance of an on-board recorder, as the experiment produces a large amount of medium rate science data that requires Ku-band for downlink. This addition to the GLO experiment adds an even greater flexibility to GLO operations.

The GLO experiment is the quintessential Hitchhiker: a prime example of taking advantage of all opportunities and resources at all times. The GLO payload operates almost continuously throughout the mission, sometimes eking significant scientific data out what could be considered trivial

Orbiter events. Through difficult flight and adverse operating conditions, the experimenters have continued to exhibit tremendous attention to experiment operations and replanning. This effort has rewarded the experimenters with success despite adversity.

Cryo Systems Experiment

The Cryo Systems Experiment (CSE) which flew on STS-63 was designed to demonstrate and characterize the on-orbit performance of several cryogenic system components contained within a standard Get-Away Special (GAS) canister. These components include two Stirling cryocoolers, a passive reversible triple-point cryogen energy storage device, an oxygen diode heat pipe thermal switch, and additional supporting electronics. CSE was designed with the anticipation that payload commanding would be sporadic and greatly unavailable. Thus the experimenters designed a largely self-sufficient experiment with automated timelines. Although the CSE mission achieved total mission success, the experimenters noted that early insight into the resources available during payload development could have broadened the scope of their experiment.

HITCHHIKER 2000

Future Trends In Mission Operations

Both the human and technological factors within the Hitchhiker Project continuously evolve to new levels of mission preparedness and support. An important concept in mission operations is that there is no end in sight to this evolution of ideas and processes. Each success and each setback teaches valuable lessons for use in future flights.

Much like Hitchhiker operations, the POCC constantly evolves to best take advantage of technological capabilities of the Hitchhiker system. Hitchhiker plans to soon adopt a system of electronic flight documentation transfer. These documents are currently replanned and distributed daily via fax protocol. The adoption of electronic data transfer within the POCC will lessen the flow of paper products and decrease time-consuming practices such as faxing and photocopy. Hitchhiker is also currently investigating the possibility of increasing the capabilities of the various display systems in the POCC.

Technological advancements and the world-wide adoption of the information superhighway have made the concept of remote Hitchhiker Operations Centers both possible and practical alternatives to pursue. Travel of personnel and shipment of equipment consume a significant percentage of a customer's budget, thus limiting funding available for other pursuits. Remote POCCs make sense given current technology and today's fiscal reality.

During the STS-63 flight, the GLO experimenters forwarded near-real-time science data to their facilities at the University

of Arizona over the Internet. Hitchhiker will soon provide mission information and potentially real-time data on-line during flights.

Hitchhiker mission operations personnel continue to endeavor for continuous improvement, always through implementation of lessons learned. Mission operations responsibilities are not over after the payload deactivates or even once the Orbiter comes home. As scientists will spend months, perhaps years, analyzing their data with a fine tooth comb, the Hitchhiker operations group will review every success and shortcoming encountered during the flight, and strive to implement the lessons learned through all future operations.

As Hitchhiker Payloads become more complex, the requirements and operations become more demanding. Double Hitchhiker payload complements consisting of numerous experiments, two avionics, and two mounting structures, will be manifested on many coming flights. These payloads are comprised of a vast diversity of experiments, ranging from cryo-experiments, atmospheric spectrographs, and deployables, to Global Positioning System (GPS) systems and laser altimeters. Future Hitchhiker flights may also include Space Station based experiments and movable Hitchhiker carriers onboard the Orbiter. With mission goals becoming more ambitious, the importance of mission operations preparedness grows increasingly clear.

By coordinating a comprehensive approach to mission operations, with attention to all phases of payload development, from the initial definition of payload requirements, through the integration of the objectives into a cohesive mission operations plan, through simulations and testing, and finally through the implementation of the plan in real-time, the mission operations group plans to ensure the greatest possible mission success for increasingly demanding payloads.